Rabbits, Vegetation and Erosion on Macquarie Island

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Rabbits were introduced to subantarctic Macquarie Island in about 1880. Selective grazing by rabbits has been important in changing the floristic composition and structure of grassland and herbfield vegetation, and the effects of grazing and burrowing activities on erosion have concerned scientific visitors to the island for some years.

Re-examination in 1980 of sites first documented in 1958 shows increases in erosion at some sites, and revegetation of some areas. Photographic documentation is provided for both sets of observations, and changes noted in the 1980 photographs are discussed. The role of rabbits in erosion of grassland sites is difficult to assess, and may in the past have been overestimated.

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INTRODUCTION

Macquarie Island (54°30'S, 158°57'E) is a small subantarctic island with a moist, cool, windy, oceanic climate. The vegetation includes tussock grassland, herbfield, fen and bog communities, and feldmark (Taylor, 1955).

Since their first introduction in 1879 or 1880 (Cumpston, 1968), rabbits have spread over most of the island and their numbers have increased dramatically. Their population was estimated at 50 000 in 1956, 150 000 in 1965-6 (Sobey *et al.*, 1973), 50 000 in 1974 (Skira, 1979) and up to 150 000 in 1977-78 (Copson *et al.*, 1981). The introduction of rabbits appears to have affected a number of components of the environment. They form the major item of food for feral cats on the island (Jones, 1977). Taylor (1979) described the role of rabbits in the demise of the Macquarie Island parakeet. The effect of rabbit grazing on the floristic composition and structure of tussock grassland and herbfield was described by Taylor (1955), and further discussed by Costin and Moore (1960), Johnston (1966) and Jenkin *et al.* (1981). The effects of rabbit grazing and burrowing on erosion have concerned scientific visitors to the island for some years, and have been the subject of several reports. Taylor (1955) and Costin and Moore (1960) concluded that selective grazing by rabbits of the stabilizing species in grassland, aggravated by burrowing, has substantially accelerated erosion of steep slopes. Johnston (1966) and Griffin (1980) concluded that rabbit-induced erosion is of minor importance in the overall erosion picture on Macquarie Island. Griffin (1980) considered that soil creep is the major erosion mechanism on the island, and that rabbit grazing has had little influence on this.

COMPARISON OF PHOTOGRAPHS

Eight sites, initially photographed in connection with a study of the role of rabbits in erosion in December 1958 (Costin and Moore, 1960) were revisited and rephotographed during January and February 1980. The sites show some changes over

the 21-year period between the two sets of photographs. There have been some increases in erosion (deepening of gullies, increased stone exposure in bare peat areas) and revegetation of some areas. Comparison of the photographs and a discussion of changes in the sites follows. Vascular plant nomenclature follows that of Greene and Walton (1975) except for *Luzula crinita* which follows Edgar (1966). Bryophyte nomenclature follows Seppelt (1980).

Figure 1: These steep slopes on which *Poa foliosa* tussock occurs appear unchanged in 1980 compared with 1958. Immediately above the limit of the photograph, however, rabbit grazing is evident at the top of the steep grassland slopes having spread downwards from the gentler herbfield slopes above.

Figure 2: The area of bare peat in right foreground has enlarged by 1980, compared with 1958. The *Poa foliosa* tussocks on the knoll are stunted. The area of white (dead) *P. foliosa* in the 1958 photo is, in 1980, occupied by a *Luzula crinita — Festuca contracta* short tussock vegetation amongst which shoots and small clumps of *P. foliosa* are growing quite prolifically. Present vegetation on the knoll includes *Acaena minor, Azorella selago, Colobanthus muscoides, Epilobium linnaeoides, Festuca contracta, Luzula crinita, Poa foliosa, Ranunculus biternatus, Breutelia pendula, Dicranoloma billardieri, Ditrichum strictum, Rhacomitrium crispulum.*

Figure 3: The dark area of stable tussock (*Poa foliosa*) in the 1958 photo appears unchanged in 1980. The white areas are now grassland with *Agrostis magellanica — Luzula crinita* dominated vegetation forming more or less continuous cover.

Both the fresh 'peat flow' landslip area (p) and the tumbled area (t) below it in the 1958 photograph have, in 1980, a complete plant cover. The present vegetation in both 'peat flow' and 'tumbled' areas is similar (unpublished quadrat data, J. J. Scott), including: *Acaena minor, Agrostis magellanica, Epilobium linnaeoides, Luzula crinita, Poa annua, Ranunculus biternatus, Breutelia pendula, Drepanocladus* sp., *Marchantia berteroana, Thuidium furfurosum.*

To the west of the peat flow area are a number of old tussock bases, (b) presumably rabbit grazed, some now overgrown with *Luzula crinita* and *Acaena minor.* There is abundant evidence of rabbits in the area of photograph 3: rabbits, burrows, squats and grazed tussock are all to be seen. In the lower left-hand corner of the 1980 photo is an area of landslip which has occurred since 1958. The ridge (r) between the old and the new slip areas is covered with 'terracettes' the origin of which is ascribed by

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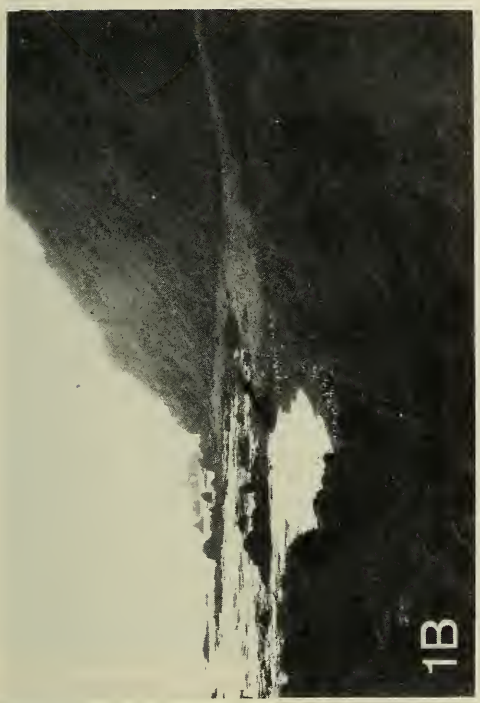
Fig. 1. From a few metres southeast of Hurd Point hut, looking to west. In all figures, photographs (**A**) taken in 1958 by A. B. Costin, previously published in Costin and Moore (1960), photographs (**B**) taken in 1980 by P. M. Selkirk. Letters on photographs are discussed in text.
Fig. 2. From about 150 m altitude on west side of scree-slope track above Hurd Point hut, looking down onto knoll to west of scree slope.

Fig. 3. North of Windsor Bay, south of Hurd Point-Caroline Cove track, taken from base of rocky outcrop to north of track.
Fig. 4. Above Hurd Point, west of scree-slope track, on slope above hill in Fig. 2.

Fig. 5. Above Hurd Point, east of scree-slope track, on plateau edge. Photograph **B** taken from closer to background ridge than photograph **A**.
Fig. 6. On Hurd Point-Caroline Cove track, below rocky knoll from which Figs 3 and 7 were taken.

*Fig. 7.** East of Petrel Peak, north of Windsor Bay, south of Fig. 6, immediately to east of Fig. 3.
*Fig. 8.** In Jessie Niccol Creek valley, from point at which Overland Track crosses south arm of Jessie Niccol Creek, looking northwest toward Mt. Blake.

* Note that in Costin and Moore (1960) captions for photographs 7 and 8 were reversed.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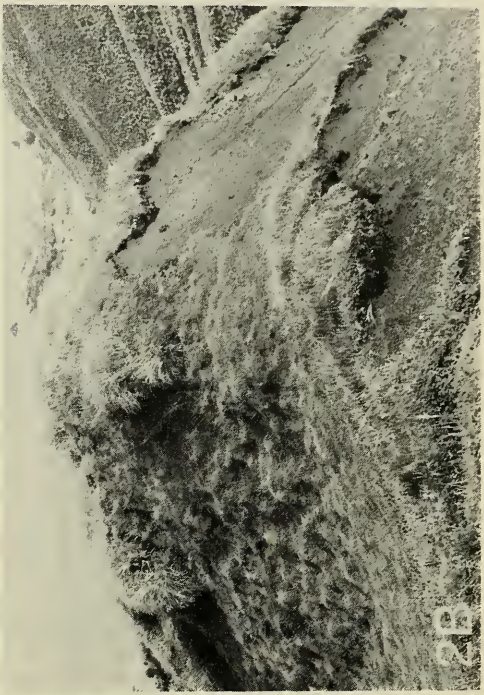


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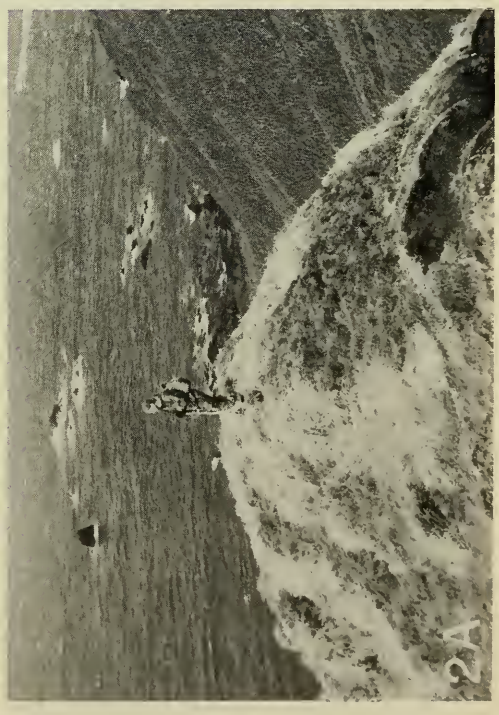
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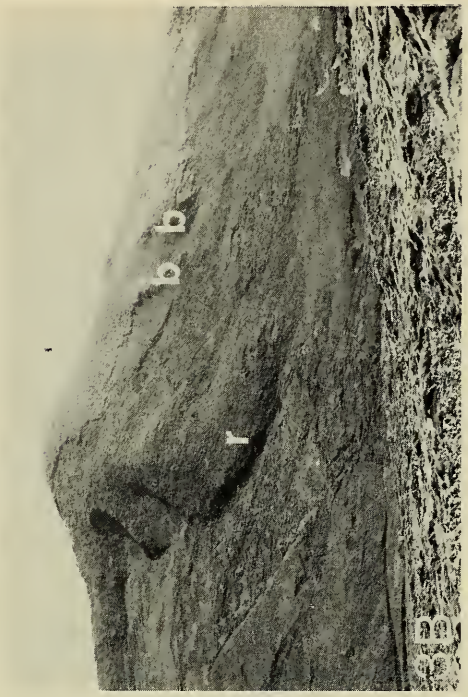
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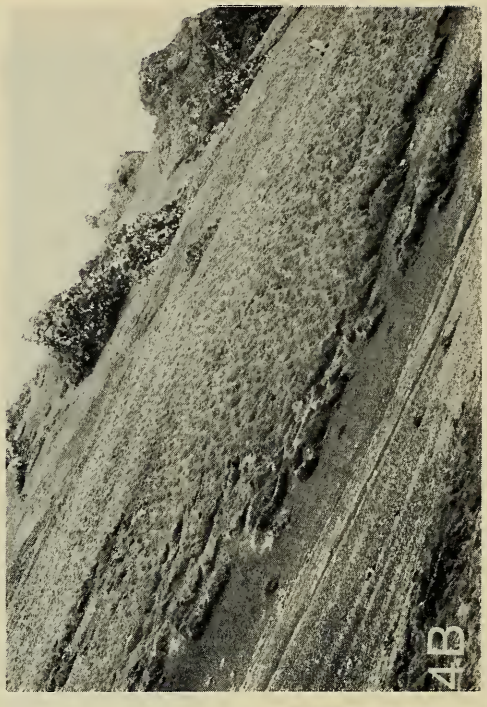
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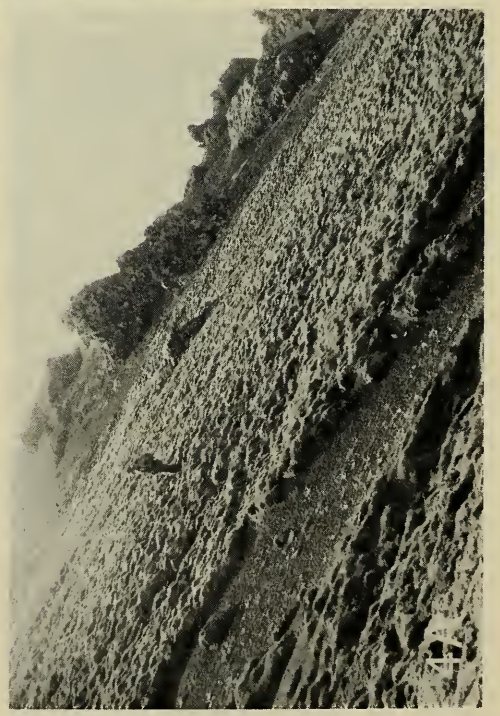
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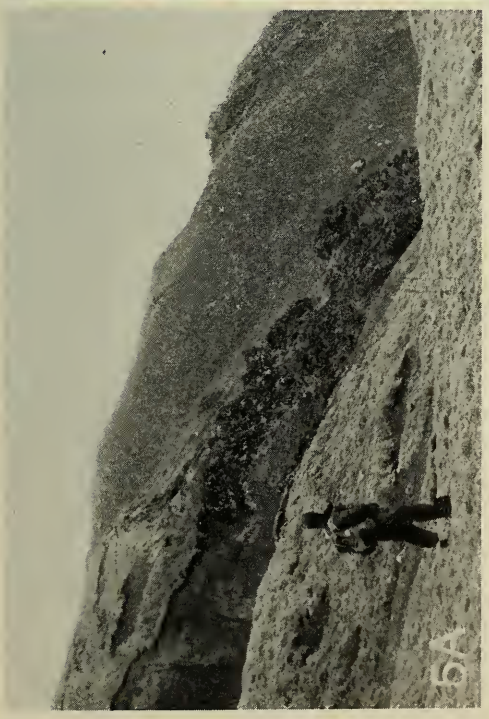
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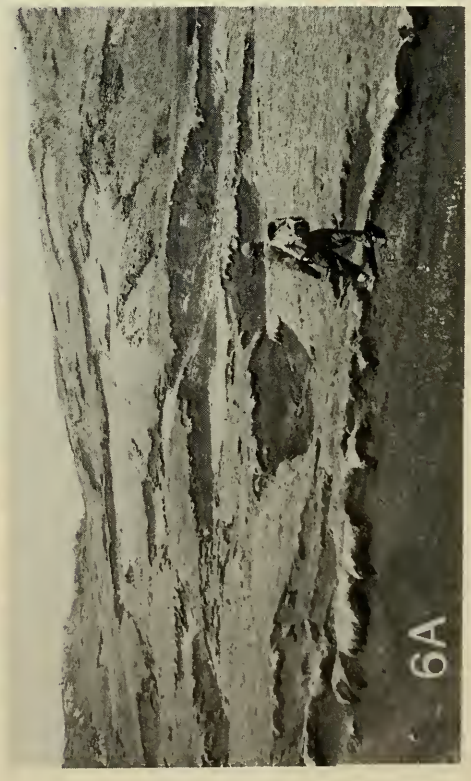
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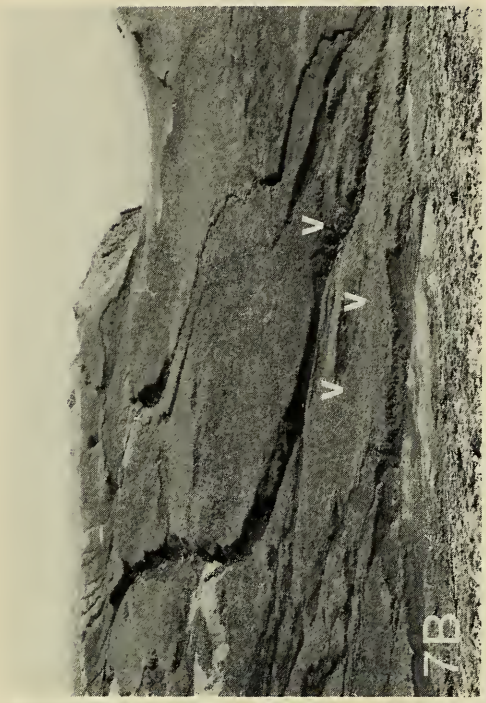
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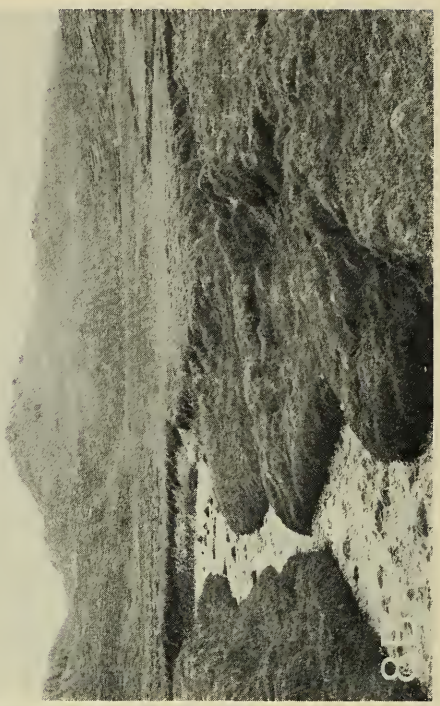
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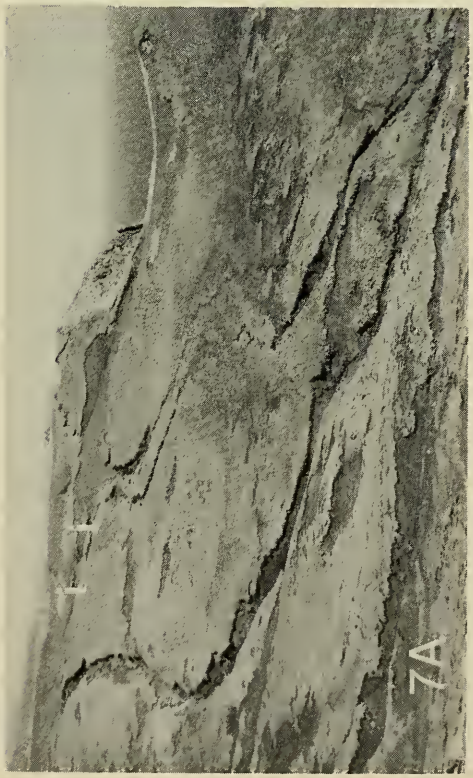
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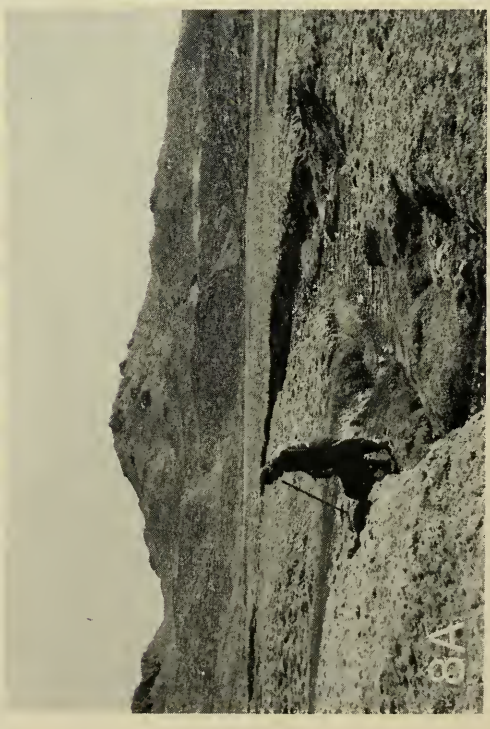
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Griffin (1980) to creep, solifluction and/or small scale slumping processes. We believe the terracettes are initiated by small-scale slumping, then may be aggravated by rabbits using them for squats and territorial digs, and the whole ultimately overgrown by vegetation (J. J. Scott, unpublished data).

Figure 4: The tongue of vegetation on the far side of the bare peat area in the 1958 photograph is, in 1980, an elongated island. The bare peat area has enlarged slightly, with a greater area of bare stones, and appears to be forming into a stony erosion pavement which should offer some protection from frost-heave, wind- and water-erosion to the remaining peat (Wimbush and Costin, 1979; Totterdell and Nebauer, 1973) allowing its colonization by mosses and angiosperms.

Figure 5: The areas bare of vegetation on the background ridge are similar in area in the two photographs although perhaps more stones are exposed in 1980. The 1958 photograph caption describes rabbit burrowing undercutting dead tussocks above the soil slip in the left background, but by 1980 there is no evidence of tussock grass having been there very recently. Rabbits were still active in the area in 1980. On the background slope (25°), present vegetation includes: *Acaena magellanica, Agrostis magellanica, Azorella selago, Cardamine corymbosa, Epilobium nerterioides, Luzula crinita, Ranunculus biternatus, Stellaria decipiens, Breutelia pendula, Drepanocladus* sp., *Psilopilum australe, Rhacomitrium crispulum*.

The present vegetation on the gentle slope (5°-15°) of the foreground ridge, much less prone to erosion than the steeper ridge behind, includes: *Acaena minor, Cardamine corymbosa, Epilobium nerterioides, Luzula crinita, Ranunculus biternatus.*

Figure 6: The total area of bare sites has not altered substantially between 1958 and 1980, but some changes are visible. In the centre of the 1980 photograph a larger area of stony pavement is visible than in 1958, exposed presumably by wind- and water-erosion of surrounding peat particles. There is in 1980 a more distinct drainage line (d) connecting the two non-vegetated areas.

Figure 7: In the bare areas on the upper slopes, gullies have deepened and some 'islands' of vegetation (i) have disappeared since 1958, presumably by the action of frost, wind and water. Lower down the slope, gullies have deepened, exposing a greater area of bare soil along the gully sides. Other areas, bare in 1958, show some revegetation (v) in 1980.

Figure 8: The creek gully in 1980 is somewhat infilled at its junction with the small tributary from the northwest, compared with the 1958 photograph. The infill material has presumably been brought down by the tributary creek. Since its deposition it has been densely covered with bryophytes. Upstream of the junction with the tributary, however, the creek gully still has quite steep sides as in 1958.

General Discussion

In trying to assess the contribution of rabbits to soil erosion on Macquarie Island, a number of factors must be considered: effect of rabbit activities (burrowing, squats, territorial digs, grazing), size of rabbit population, extent of rabbit activities, and other factors contributing to surface instability.

Undercutting of tussocks by rabbit burrowing was described by Costin and Moore

(1960). The suggested role of rabbit squat and territorial digging activities in accentuating terracettes has been mentioned above. It is by their selective grazing that rabbits exert most effect on the Macquarie Island environment. Areas may be completely denuded of their vegetation when this was composed entirely of palatable species. These areas may be subject to erosion until colonized by less palatable and/or grazing-adapted species. An example is a steep slope above the beach just south of Nuggets Point beach, previously clothed with *Stilbocarpa polaris* and a little *Poa foliosa* on which rabbit grazing was severe during 1978-9 (G. Copson, pers. comm.). The area was bared when the *Stilbocarpa* was grazed down to its rhizomes. In 1980, rapid colonization of the soil surface was being achieved principally by *Marchantia berteroana* (via its abundantly-produced gemmae), but also by *Poa annua, Epilobium linnaeoides, E. nerterioides* and *Cardamine corymbosa. Marchantia berteroana* seemed only rarely to be touched by the rabbits which were still present in the area. Erosion of the surface appeared minimal.

The recolonization of areas bared by rabbit grazing appears similar in general terms to the recolonization of areas bared of vegetation by landslips, but with some important differences (J. J. Scott, unpublished data). These arise because landslips commonly remove all vegetation plus a peat layer, while selective grazing by rabbits usually leaves some (possibly less palatable) vegetation on the site. For example, grazing on the coastal slopes usually removes the dominant species *Poa foliosa* and *Stilbocarpa polaris*, allowing remaining subsidiary species such as *Ranunculus biternatus, Acaena minor* and *Agrostis magellanica* to achieve local dominance, in similar fashion to the infilling of gaps between senescing *Poa foliosa* tussocks (Ashton, 1965). A landslip removes both dominant and subsidiary species, as well as surface litter, seeds and underground rhizomes in a peat layer of varying thickness. Revegetation proceeds much more slowly than on areas bared by grazing. In the absence of further grazing once an area has been bared, both landslip surface and areas grazed by rabbits can eventually be revegetated by their former dominant species. However, if regeneration of *Poa foliosa* and *Stilbocarpa polaris* is suppressed by continued grazing of landslip- or rabbit-bared surfaces, a short tussock grassland characterized by *Agrostis magellanica, Luzula crinita* and *Acaena* spp. develops.

In areas whose dominant vegetation includes a mixture of palatable and unpalatable species, selective grazing by rabbits can have a very marked effect on species composition. For example, the rabbit population of the Flat Creek valley, near Bauer Bay, was dramatically reduced by myxomatosis during winter 1979. The quantities of *Pleurophyllum hookeri, Stellaria media* and *Cerastium fontanum*, all preferentially eaten by rabbits, were observed to increase noticeably in this valley between the beginning and the end of the 1979-80 summer.

The floristic composition of the short tussock grasslands and herbfields has been particularly affected by rabbit grazing. *Pleurophyllum hookeri* now seems less widespread in the herbfields than Taylor's (1955) photographs and descriptions would suggest. The highly palatable *Pleurophyllum* is badly damaged when rabbits graze the leaves right down to the stem stump. Species which are now more abundant in the herbfield than Taylor's (1955) descriptions suggest may be less palatable to rabbits (e.g. *Luzula crinita*) or able to withstand and thrive despite grazing, by virtue of abundant lateral shoot growth (e.g. *Acaena* spp.), tillering (*Poa annua, Agrostis magellanica*) or seed set (*Acaena* spp., *Poa annua, Agrostis magellanica, Uncinia compacta*). Copson *et al.* (1981) note that the majority of rabbits live in the herbfield vegetation, including the short tussock grasslands mentioned above. Few rabbits live in the tussock grassland, bog, fen and feldmark formations as described by Taylor (1955), although these vegetation types are grazed by rabbits from nearby herbfield areas (Copson *et al.*, 1981).

Early descriptions (Cumpston, 1968) and recent estimates (Sobey *et al.*, 1973; Skira, 1979; Copson *et al.*, 1981) of rabbit numbers on the island are consistent with the suggestion that, in common with introduced species elsewhere, the rabbit population on Macquarie Island was low for a long period after its introduction, went through a period of rapid expansion to a maximum, perhaps beyond the capacity of the habitat to support the numbers, then fell again to a lower level, in balance with the capacity of the habitat to support it. Within this general picture, numbers appear to have fluctuated: for example, a peak between 1880 and 1906 is discussed by Taylor (1979) using data from Cumpston (1968), and a peak occurred in the 1977-78 summer due to several successful breeding seasons preceding it (Copson *et al.*, 1981). It is suggested by Copson *et al.* that annual population fluctuations are a result of seasonal changes in weather, with extended drier periods leading to higher survival rate of kittens.

Dense rabbit populations have occurred in different places on the island at different times (maps, Sobey *et al.*, 1973). Detailed rabbit counts have been made in recent years by officers of the Tasmanian National Parks and Wildlife Service but the size of the population at any time is not easy to estimate. The times of peak populations in the past may never be known, but it may be assumed that maximal effect by rabbits on an environment would correspond with peak populations in the area. Such an area would be especially vulnerable to accelerated erosion, if there were a lag between the initial damage to the taller-growing dominant plants (*Poa foliosa, Stilbocarpa polaris*) and the subsequent succession of lower-growing herbs and mosses, as in Figs 2, 3 and 5. The observations of Costin and Moore (1960) may have been made soon after a period of maximal rabbit population in the Hurd Point area, and consequently maximal deleterious effect on the local environment. Although rabbit activities may have provided a trigger for more than usual peat instability, it is clear that the predicted extension of damaged areas (Costin and Moore, 1960) is not occurring, except locally.

Griffin (1980) discussed a number of erosive forces active on Macquarie Island, namely soil creep, landslips triggered both by unusually heavy rain periods and by earthquakes, wind erosion and rabbit activities. In addition, royal penguin, gentoo penguin and giant petrel activity on some of the lower coastal slopes contributes locally to the erosion of peaty soil between *Poa foliosa* tussocks, thereby affecting the balance and stability of the tussocks. After prolonged rain, slipping of these unstable situations may occur.

In the presence of these other erosive forces on Macquarie Island, the role of rabbits in initiating and contributing to continued erosion of grassland areas is difficult to assess, and may in the past have been overestimated. Through their selective grazing, however, rabbits have had major effects in changing the floristic composition and structure of much of the original grassland and herbfield vegetation.

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